Simple and Cheap Preamps

For the Simple and Cheap Transverters

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Many hams have built my Simple and Cheap transverters (w1ghz.org) and desire a little more performance. A simple ¼ watt amplifier[1] gets the transmitter up into the pipsqueak range, adequate for many rovers, and a preamp can improve receive performance.

There are some good preamps on the market, but most of them cost more than a whole transverter. With the right MMIC, it should be possible to make a good preamp as simple as the transverter. I recently described some unconditionally stable LNAs [1] with very good performance, but those MMICS come in a tiny leadless package that can't be soldered by hand. Mike, N1JEZ, was able to assemble them by reflow soldering in a toaster oven, but something solderable by a human would be preferable.

While I was ordering parts from Mouser for the LNAs, I found a MMIC intended for GPS receivers, specified with NF=0.4 dB. This part, the CAEL CA3509M4, comes in a tiny package with 4 leads for less than $2. I ordered some to see if they would work at 1296 MHz – that transverter has a rather high noise figure and needs some help.

Simple Preamp

Since the parts were cheap, I had ordered some hoping to find a way to fit them on an existing PC board. When I opened the package and looked at the data sheet, I found that they would fit on my "Universal MMIC" board, the same one used for the ¼ watt amplifier. I built several with part values close to the data sheet circuit. They worked well at 1296 MHz, but not at lower frequencies, so I built another with larger capacitor and RF choke values, shown in Figure 1.

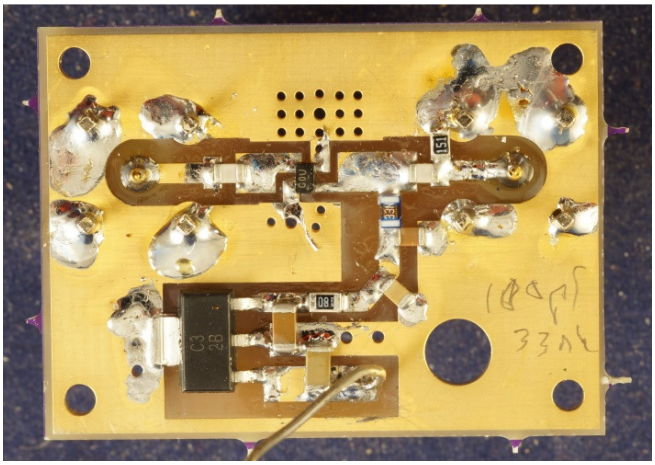

Figure 1 – Cheap and Simple Preamp

The larger component values improved low frequency performance, so I built three more to verify that it wasn't just a lucky one. Noise figure for seven preamps is shown in Figure 2. The three units with data sheet component values have very little gain below 400 MHz, while the other units with larger component values have NF well under 1 dB from 2 meters through 1296 MHz. Gain is about 20 dB at the lower frequencies, falling to about 17 dB at 1296 MHz.

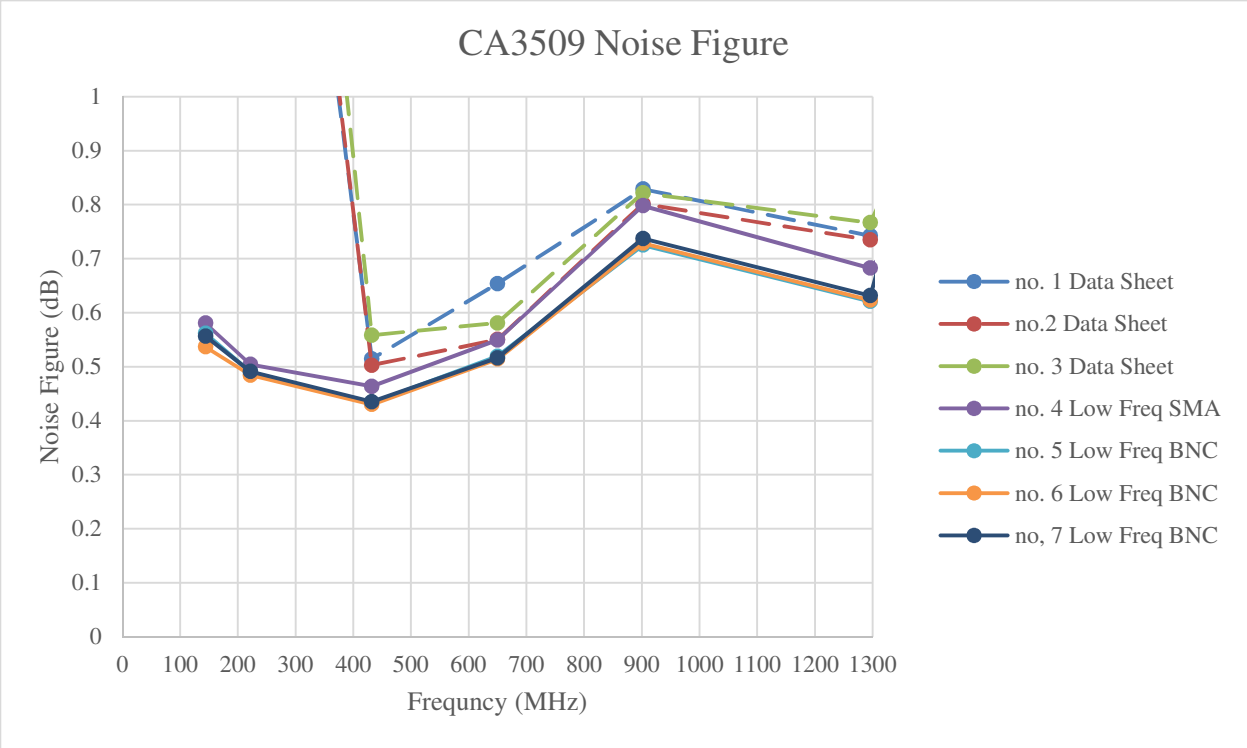

Figure 2 – Simple and Cheap Preamp Noise Figure

The preamps should also be useful at 2300 and 3400 MHz, with NF under 1.5 dB, but with less gain, around 12 dB at 2304 and 10 dB at 3400, as shown in Figure 3. The units with SMA connectors look a little better at the higher frequencies.

Noise Figure Calibration

At various conferences, I have acquired a half-dozen very low noise LNA for future EME use (still working on it). These all have the original data from the hams who built them, so I measured them for comparison, and found that my measurements were slightly higher:

- 144 & 432 MHz < 0.1 dB difference
- 902 MHz 0.23 to 0.25 dB higher
- 1296 MHz 0.04 to 0.17 dB higher

Assuming that the R&S instrument has traceable calibration, we can conclude that Figures 2 is on the conservative side. Use any fudge factor you prefer.

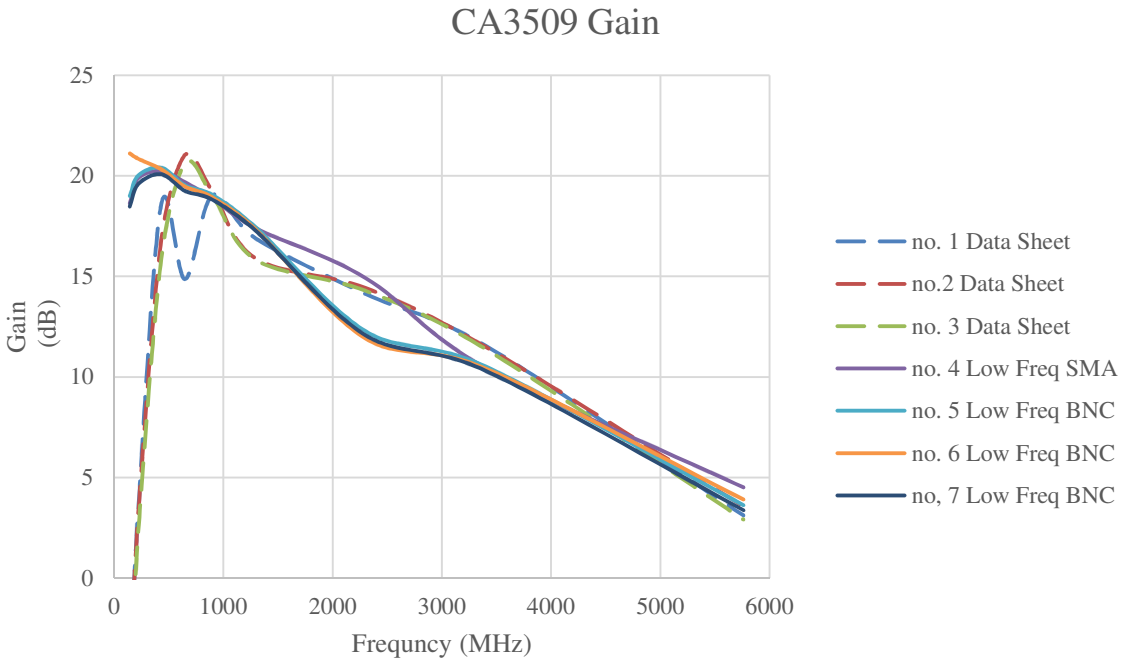

Figure 3 - Simple and Cheap Preamp Gain

The schematic is also simple, shown in Figure 4. The data sheet values are C1=22pf, C2=4pf (I used 5pf), C3=1000pf, and L1=6.2nh (I used 8.2nh); these have dashed lines in Figures 2 and 3. For the lower frequency version, C1, C2, and C3 are all 100pf and L1=33nh. Fiddling with component values might optimize for one band, but I'm sticking to simple.

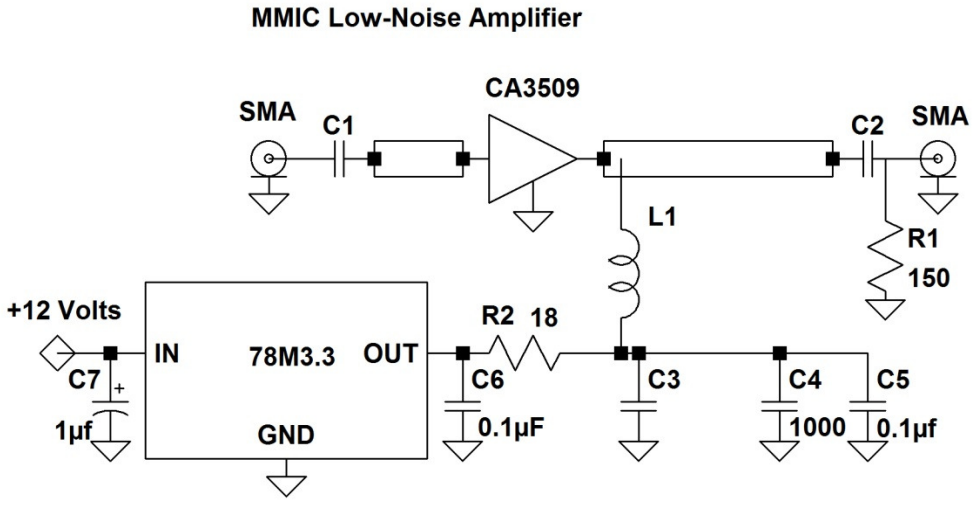

Figure 4 – Cheap and Simple Preamp schematic diagram

Note the resistor at the output – this is a hint that this part is not unconditionally stable, and this resistor improves stability, at the cost of a few dB of gain. Resistor R2 reduces the voltage to 3.0 volts at the device, but isn't needed – NF is slightly better at 3.3 volts

Construction

Construction is pretty straightforward, as shown in Figure 1 – just solder the components to the PC board. The trickiest part is the small MMIC, where magnification will help. I use a stereo microscope, but a good magnifier should be adequate. I used ordinary SMT components and cheap SMA or BNC connectors, so total cost is under $10.

Hams love to experiment, so you could probably improve the noise figure slightly by using better capacitors and SMA connectors, and perhaps a bit of tuning. Chopping the board to use edge mount connectors might improve performance at the higher bands.

The last three preamps were built with BNC connectors rather than SMA – I had some PC boards with BNC footprints rather than SMA and I grabbed them by mistake. I didn't notice until all the other parts were assembled. The performance doesn't seem to be affected. It took about 1.5 hours to build all three.

The Universal MMIC PC board is sized to fit in the smallest Pomona box (Model 3754), like Figure 4, but the box costs more than the preamp. A small Altoids box is an alternative, or the board could just be mounted in a transverter case.

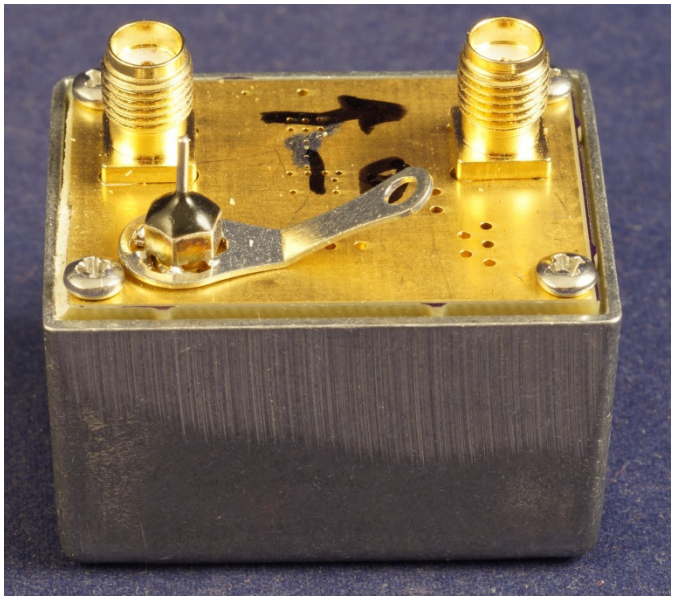

Figure 2 – Preamp board in Pomona box

Summary

These simple preamps will improve performance of the Simple and Cheap transverters and probably many other rigs. They use cheap parts and are easy to build with no tuning required.

These are broadband amplifiers, so they will amplify all the unwanted stuff as well. The CA3509M4 is a relatively low power part, drawing about 15 mA, good for rovers, but don't expect great intermod performance with strong out-of-band signals. In most good locations, there is a lot of crap -- a good filter can make a huge difference and is highly recommended.

Notes:

1. Paul Wade, W1GHZ, "A ¼ Watt No-tune Amplifier for Cheap and Simple Transverters," *Proceedings of the 54th Conference of the Central States VHF Society*, ARRL, 2022, pp.168-171. Also http://www.w1ghz.org/PCBproj/Notune_Quarterwatt_Amplifier.pdf
2. Paul Wade, W1GHZ, "Very Low-Noise Unconditionally Stable MMIC Amplifiers," 47th Eastern VHF/UHF/Microwave Conference (2024), http://www.newsvhf.com/conf2024/PresPapers/W1GHZ-Very_Low_Noise_Unconditionally_Stable_MMIC_Amplifiers.pdf
3. Mike Seguin, N1JEZ, "Surface Mount Assembly with a Toaster Oven," 47th Eastern VHF/UHF/Microwave Conference (2024), http://www.newsvhf.com/conf2024/PresPapers/N1JEZ-Surface_Mount_Assembly_with_Toaster_Oven.pdf